Proceedings of the 7th Hungarian Congress on Plant Physiology, 2002
S6-03

Volume 46(3-4):221-222, 2002
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Seasonal carbon-balance of a semi-desert temperate grassland ecosystem over a year period

J Balogh[1]*, Sz Czóbel[2], A Juhász[2], Sz Fóti[2], Z Nagy[2] , Z Tuba[1,2]

[1]Global Climate Change and Plants Research Group of Hungarian Academy of Sciences, Szent István University, Gödöllő Hungary, [2]Department of Botany and Plant Physiology, Faculty of Agricultural and Environmental Sciences, Szent István University, Gödöllő, Hungary

ABSTRACT Temperate grassland ecosystems are important components of the global carbon cycle. Our object of investigation, the semi-arid sand grassland community (*Festucetum vaginatae danubiale*) occurs widely in Hungary. A closed-loop portable IRGA system connected to a chamber appropriate for stand-scale measurements was used to measure CO_2-exchange over a semi-desert temperate grassland from November 2000 to November 2001. Daily and yearly carbon balances were calculated by integration of net CO_2 assimilation rates. The investigated sandy grassland proved to be a relatively strong source of carbon (-131.48 g $C.m^{-2}.year^{-1}$) as calculated over the year, probably caused also by nutrient limitations (characteristic of these grasslands) during the short periods when water supply was not limiting photosynthesis.
Acta Biol Szeged 46(3-4):221-222 (2002)

KEY WORDS

carbon balance
temperate semi-desert sand grassland
chamber technique

Temperate grasslands cover large areas of the Earth's vegetation (Coupland 1992), and they are located in one of the regions where the impact of global climate change is predicted to be high (Mitchell et al. 1990). The temperate grassland surface has large and increasing areas with arid climate. Even in the middle of Europe, Hungary has areas where the relatively low and unevenly distributed yearly precipitation and the sandy soil with its small water holding capacity result in a semi-arid grassland

In grasslands most of the carbon can be found below-ground (in the soil organic matter and in the below-ground plant parts) and this feature provides temperate grasslands with many characteristics, which might be essential from the global carbon cycling aspect. In order to learn and quantify the role of temperate grassland ecosystems in carbon cycling and to predict their responses to a possible climate change, intense measurements on their CO_2 exchange are required. Although the semidesert temperate grassland ecosystems are substantial and integrated elements of the temperate grassland zone we are not aware of any long-term C-balance measurements for semidesert temperate grassland.

In this work we report on CO_2 exchange measurements in a semiarid sand temperate grassland ecosytem over a year period carried out by chamber technique.

Materials and Methods

Study site

The measurements were conducted in a semi-desert sand grassland, near Vácrátót (latitude 47°16'N, longitude 19°16'E, elevation 180 m).

The semi-arid grassland (*Festucetum vaginatae danubiale*) distributed in the Carpathian Basin, evolved on sandy soils and has semi-desert features due to edaphic causes (Fekete et al. 1988). This community is dominated by grasses *Festuca vaginata* and *Stipa capillata.* Average cover by vascular plants is 30-40 % and the gaps between the individuals are exposed to direct solar radiation. The temperature of the sand surface regularly reaches 60°C at noon. These inhospitable microsites are inhabited by the cryptogamic plants, first of all mosses with a 18-20% contribution to the total cover.

Physiological methods

The field measurements were carried out 20 times from November 2000 to November 2001. CO_2-exchange (net photosynthesis and dark respiration), transpiration, air temperature, relative humidity, vapour pressure, and stomatal conductance were measured by using a portable closed-loop IRGA (LI-COR 6200, operated in absolute mode) sampling the air in a plexi-chamber of 60 cm diameter and 70 cm height, with three replicates in five plots. Soil respiration rates were measured in three replicates in three plots by using the same IRGA with a plexi hemisphere chamber of 20 cm diameter. Canopy CO_2-assimilation rates were corrected by soil respiration values.

Soil water content was measured by a TDR reflectometer (Delta-T Devices) in three replications at 5, 10, 20 cm soil depths. PPFD was recorded and LAI was estimated using sunfleck ceptometers (Decagon). Canopy-surface temperature was measured by an infrared thermometer (Raytek MX4).

Daily and yearly carbon balances

Daily carbon balances were calculated by integration of the net CO_2 assimilation rates after correction with the dark respiration values. Yearly carbon balances were estiamted by extrapolating the daily values.

*Corresponding author. E-mail: janko@fau.gau.hu

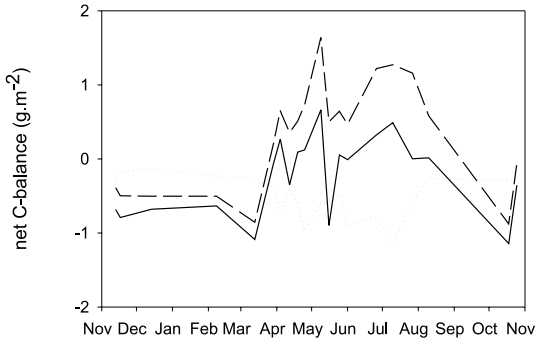

Figure 1. The course of carbon-balance corrected (dashed line and not corrected (solid line) for soil respiration (dotted line) of the semi-desert sand grassland ecosystem.

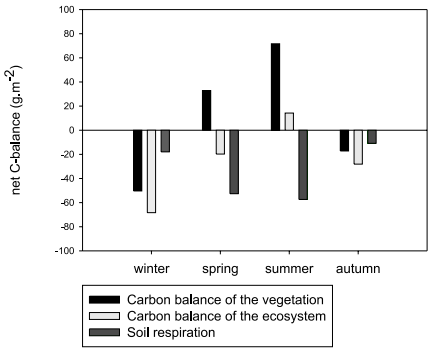

Figure 2. Integrated seasonal carbon-balance of the semi-desert sand grassland.

Results and Discussion

The maximal net carbon uptake rate of about 0.14 mg C .m^{-2}.s^{-1} was observed at 15.06.2001. The highest soil respiration rate was 0.017 mg C m^{-2}.s^{-1}. The daily seasonal C balances during the time of maximal photosynthesis were about 0.66 g C.m^{-2}.day^{-1}., while the minimum value was -1.124 g C.m^{-2}.day^{-1} at 18.11.2001. The calculated net C balance over the year was –131.48 g C.m^{-2}.

The course of a daily net carbon balance of ecosystem, grassland vegetation and soil respiration over an investigated year is shown in Figure 1. The pattern of the seasonal carbon balance in ecosystem, the vegetation and soil respiration is depicted in Figure 2.

The vegetation displayed net positive carbon balance in the spring and in the summer while in the autumn and winter it showed a negative balance with minimum values in the winter. The highest soil respiration values in the year were measuresd in the spring and summer period while the lowest ones in the autumn and winter. As a result of the seasonal changes in the ecosystem carbon balance components the ecosystem had positive net carbon balance only in the summer.

Annual ecosystem carbon balance value at our investigated ecosystem is lower then in other grasslands in the temperate region (Sims and Bradford 2001; Frank and Dugas 2001), where annual carbon balances are ranging: from 6.2 g C.m^{-2}.$year^{-1}$ to 34 g C.m^{-2}.$year^{-1}$. In contrast of slightly positive annual yearly carbon balance of the mentioned grasslands our sampling site had a negative value in the investigation period. As a consequence the investigated temperate semi-desert grassland does have a negative annual carbon balance and therefore it can be considered as a CO_2 source. At the same time large interannual variability of the carbon balances of prairie ecosystems has been reported (Frank and Dugas 2001), pointing to the necessity of continuing such studies for several years in order to achieve more sound estimates on carbon balance of these grasslands.

By comparison the highest daily carbon uptake values of the investigated sandy grassland (0.66 g C.m^{-2}.day^{-1}) and that of a semi-desert prairie grassland (1.54 g C.m^{-2}.day^{-1}; Sims and Bradford 2001), our grassland has lower photosynthetic and carbon incorporation capacity.

Acknowledgements

This work was supported by the Hungarian Scientific Research Found (OTKA-32586 project).

References

Coupland RT (1992) Approach and generalizations. In Coupland RT ed., Ecosystems of the World 8A, Natural Grassland, Introduction and Western Hemisphere, Elsevier, New York, pp.1-6.

Dugas WA, Heuer ML, Mayeux HS (1999) Carbon dioxide fluxes over bermudagrass, native prairie, and sorghum. Agricultural and Forest Meteorology 93:121-139.

Fekete G, Tuba Z, Melkó E (1988) Background processes at the population level during succession in grasslands on sand. Vegetatio 77:33-41.

Frank AB (2002) Carbon dioxid fluxes over a grazed prairie and seeded pasture in the Northern Great Plains. Environmental Pollution 116: 397-403.

Frank AB, Dugas WA (2002) Carbon dioxid fluxes over a northern semiarid, mixed-grass prairie. Agricultural and Forest Meteorology 108:317-326.

Mitchell JFB, Manabe S, Meleshko V, Tokioka T. (1990) Equilibrium climate change-and its implications for the future. In: Houghton JT, Jenkins GJ, Ephraums JJ eds., Climate change, The IPCC Scientific Assessment, Chapter 5, Cambridge University Press, New York, pp. 131-172.

Sims PL, Bradford JA (2002) Carbon dioxid fluxes in a southern plains prairie. Agricultural and Forest Meteorology 109:117-134.